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SIGERIST ON ANATOMY

MEES ON SCIENCE AND SOCIETY

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To the Chapters and Clubs of Sigma Xi:

The discovery of the hidden truths of Nature is the aim of all those associated with Sigma Xi. To encourage and promote research to this end is the object of our numerous Chapters and Clubs. So simple and direct a purpose might seem easy of attainment, but those who have striven for it know how difficult it is to reach. Only by unremitting toil, patient perseverance, and the continued exercise of those habits of body and mind that lead to intellectual conquest can this end be gained. Such an accomplishment depends upon a spirit of native, tireless curiosity coupled with a willingness to undergo endless labor. It is the purpose of our Society to foster, aid, and encourage this spirit in every way. To strive for this objective calls for no mean effort, but who will venture to say that the power does not lie within our hands?

My greetings go to all in Sigma Xi.

G. H. PARKER.

GEORGE HOWARD PARKER

THE NEW OFFICERS

George Howard Parker

PRESIDENT

George Howard Parker was born in Philadelphia, Pennsylvania, December 23, 1864. His early schooling was given him at home and subsequently at a small private school after which he entered the Friends' Central School of Philadelphia. On leaving school he already had a strong bent toward natural history and in 1880 he became a Jessup Beneficiary Student at the Philadelphia Academy of Natural Sciences. In the autumn of 1883 he entered the Lawrence Scientific School of Harvard University whence he graduated with the degree of S.B. in 1887. He continued his connections with Harvard as a part-time instructor in zoology and as a graduate student till 1891 when he was granted the degree of S.D. He was then appointed to a Parker Traveling Fellowship. This he held for two years during which time he studied at the Universities of Leipzig, Berlin, Freiburg i. B., and at the Naples Zoological Station. On his return from abroad he again took up teaching at Harvard and served in its zoological department as instructor from 1893 to 1899, as assistant professor from 1899 to 1906 and as professor from 1906 to the present time. In 1921 he was made director of the Harvard Zoological Laboratory.

In 1909 he was a lecturer in the Lowell Institute and in 1914 Clark lecturer at Amherst College. In the same year he was appointed by President Wilson one of three investigators to study and report on the fur-seal herds of the Probilof Islands. In 1921 he was Harvard exchange professor to the western colleges and in 1926 he represented his University at the Third Pan-Pacific Science Congress in Tokyo after which he visited and lectured at the more important universities in Japan, Korea, and China. He has worked at many of the marine biological stations on the Atlantic and Pacific coasts of the United States and at Barro Colorado in Panama. His interests are in the fields of the comparative anatomy and physiology of the nervous system, its sense organs and its effectors, as well as in animal reactions in general. His scientific publications in the form of books and papers number over two hundred. He is a member of the National Academy of Sciences and of the American Philosophical Society, on both of whose councils he has served, and of the American Academy of Arts and Sciences of which he is president. He holds membership in over a score of scientific societies at home and abroad. In 1922 he was made an honorary member of the Yale Chapter of Sigma Xi. He is a charter member of the Harvard Chapter of this Society of which he was president in 1932-33.

LEWIS J. STADLER

HAROLD F. NORTON

Lewis J. Stadler

EXECUTIVE COMMITTEE

Lewis J. Stadler was born in St. Louis, Missouri, in 1896. His undergraduate training was at the University of Florida where he received the B.S. degree in 1917. He pursued graduate work at Missouri University and Cornell University, and was given the doctorate at Missouri in 1922. He was National Research Fellow in Genetics at Bussey Institution, Harvard University, 1925-26.

Doctor Stadler served in the United States Field Artillery in 1918. He has been successively instructor, assistant professor, associate professor in field crops, University of Missouri, and since 1929 senior geneticist, Bureau of Plant Industry, United States Department of Agriculture, conducting cooperative investigations in plant breeding and genetics at the University.

He is a member of the American Society of Naturalists, the American Society of Agronomy, the American Association for the Advancement of Science, the Genetics Society of America, Sigma Xi, Phi Kappa Phi, and Alpha Zeta. He has served as chairman of the joint Genetics Sections of A. A. A. S. and as chairman of the Committee of 100 at the Sixth International Congress of Genetics.

Doctor Stadler's chief interests in research are mutation, experimental modification of heredity, and economic plant breeding.

Harold F. Norton

ALUMNI COMMITTEE

Harold F. Norton is naval architect with the Newport News Shipbuilding and Dry Dock Company, with which organization he has been associated since 1901. Engineering ability and interests were born in him. At the time of his birth in Ashland, Kentucky, in 1874 his father and grandfather were the chief men in a new blast furnace completed just prior to that year and named The Norton Iron Works. Mr. Norton's high school education was begun in Pittsburgh and completed in Niagara Falls, and from the latter he won a New York State scholarship at Cornell University. His university course was in mechanical engineering with special emphasis on marine engineering and naval architecture. He was elected to the Cornell Chapter of Sigma Xi during his junior year, and for a few months following his graduation in 1896 was engaged with Professor Durand on an investigation of the performance of screw propellers.

Mr. Norton is a member of the American Society of Naval Architects and Marine Engineers and of the Institution of Naval Architects, London.

THE FOUNDATION OF HUMAN ANATOMY IN THE RENAISSANCE

HENRY E. SIGERIST, M.D.

Professor of the History of Medicine, and Director of the Institute of the History of Medicine, Johns Hopkins University

When we speak of the foundation of human anatomy, we immediately remember the names of two great Greek physicians who, at the end of the fourth and the beginning of the third centuries B. C., lived and worked in Alexandria —Herophilus and Erasistratus. Their names have survived the centuries, and have become a part of our anatomical nomenclature. They were not specialists in anatomy, but all-round physicians whose writings cover the whole wide field of medicine. Herophilus was chiefly influenced by the school of Cos, and wrote famous books on the pulse, on drugs, on midwifery; but then, he also wrote a treatise on anatomy in at least three books. The fragments preserved show that he had a thorough knowledge of the anatomy of the eye, the membranes of the brain, the genital organs, and the duodenum; and credit is to be given him for his recognition of the true nature of the nerves. He dissected numerous animals, and occasionally human bodies: according to an ancient tradition, even human vivisections were performed in Alexandria.

A still greater anatomist was to be found in Erasistratus. Fragments of his two works on anatomy contain good descriptions of the heart, the liver, and the brain; it was he who discovered that there are two kinds of nerves—sensory and motor. But he went still further. Being a student of Cnidos, where the tendency had always been to localize disease, he recognized that diseases have a seat, and that this seat has to be sought in the organs. In his dissections he had found anatomical alterations which seemed to have some relation to the disease from which the patient had died.

Both Herophilus and Erasistratus founded schools which continued for many centuries, and it is chiefly due to them that Alexandria was the center of anatomical studies throughout antiquity. When, in the second century A. D., Galen wanted to study anatomy, he had to go to Alexandria. This was the only place, he tells us, where you could find a skeleton. Human dissections, however, were no longer practiced, and one had to rely upon what was found by dissecting monkeys, pigs, and other animals.

And so there was anatomy long before the Renaissance. But it existed before the Alexandrian school. We can trace the beginnings in Greece back to the sixth century B. C., to the schools of the first philosophers, all of whom were scientists as well as philosophers. They observed the phenomena of nature, and endeavored to draw conclusions from what they saw, speculating about the primary cause of all things. It would have been surprising had they not extended their studies to the bodies of animals.

Yet we can go back still farther. There was always some kind of anatomical knowledge. As soon as man began talking in an articulate language, he invented names to designate the parts of the body, very much as a child does. Whenever an animal was slaughtered, be it for the kitchen or for the sacrificial altar, anatomical observations were bound to occur, and the first classification of organs was probably a distinction between edible and non-edible parts.

Primitive man must even then have been impressed by certain anatomical peculiarities, as was the paleolithic man, who, in a cave of Spain, drew the outline of an elephant, and within the picture drew a heart. Remains of a cosmic mythical anatomy are still preserved in our language. We still call the first cervical vertebra Atlas, carrying the dome of heaven, the cranium; we still speak of the Adam's Apple, the Mount of Venus, the Labyrinth.

Whenever surgical operations were performed, the surgeon must have had some kind of anatomical knowledge. The earliest surgical book preserved, the Edwin Smith Surgical Papyrus, which was originally written at the time of the Old Kingdom in Egypt, gives evidence of such anatomical knowledge. Anatomy, therefore, is a very old science; and yet ancient anatomy was of a quite different character from the anatomy that was found at the time of the Renaissance. The surgeons' knowledge, as far as it went, was topographical. It was limited to certain regions of the body. As long as surgery was restricted to a small number of operations—as was the case down to the nineteenth century—the surgeon could operate very successfully with a limited knowledge of the human body. Ancient anatomy, then, was almost entirely animal anatomy. The Alexandrians occasionally described human organs, but never *in situ*, and never systematically. First of all, anatomy had an entirely different place in the system from what it has today. One studied the structure of the body because it was a part of the realm of nature, just as one studied plants or minerals, and geography. A doctor did not study anatomy because he thought it imperative; and this was because Greek medicine had an essentially different structure from that of our medicine today. The symptoms of disease were not traced back into the organism. The concept of disease was not ontological, and if one systematized, one did not systematize disease, but rather, different types of man. Erasistratus has a unique position in Greek medicine. He took the road that we have followed, but his attempt to establish an anatomical system of medicine failed, just as Aristarchus had found no followers for the heliocentric system. Another school grew out of Alexandria—the school of the Empiricists, who declared openly that anatomy was of no use to the doctor. The same view was shared by another very popular school, the Methodicists. And as the ancient world grew old, Hippocrates became still more the dominating figure—Hippocrates, who had cured without anatomy.

The foundation of human anatomy, therefore, was the accomplishment of our western medicine. There, a necessity for the doctor to have an intimate knowledge of the human body was overwhelmingly felt, which eventually broke down completely the taboos that surrounded the human body. The body of a diseased man was always considered to be within the realm of the physician. Not so the cadaver, the attitude towards that being the result of æsthetic, ethical and religious conceptions. The cadaver was thought to be something holy, or impure, not to be touched without necessity. The Christian attitude, contrasting sharply body and soul, was by no means favorable to the development of anatomy. And yet, in spite of all this, the barriers were broken. From the beginning of the fourteenth century on, human cadavers were dissected; first in Bologna, then in other universities; and several times a year. Such anatomies were held, but they did not serve research purposes; they

were, rather, mere demonstrations illustrating the textbooks. One was still convinced that the Greeks had known all there was to know about the human body, and one dissected in order to reach a better understanding of their statements.

The Renaissance marks the turning-point in attitude of man towards anatomy, and towards the human body in general. The word "Renaissance" is a technical term from the history of art. Used first by Vasari, it became generally accepted after the publication of Jakob Burckhardt's classic book, *Die Kultur der Renaissance in Italien* (1860). What does the Renaissance mean to medicine? It certainly was not a revival of learning, for there was learning in the medieval universities. Nor was it a revival of Greek medical literature, for this had been known through translations from the Arabic since the eleventh century. Far more was it a revival of the Greek spirit of research—a new attitude of man towards his fellow-men and the world as a whole. Humanity became the ideal of the new society which grew up first in Italy—a humanity that meant the highest possible development of the personality. And whenever strong personalities come forward, the traditional authorities are in danger of being uprooted. One essential feature of the period of the Renaissance is the discovery of the world, the great world that was unknown to the Greeks; new continents, with new plants, new species of animals, new races of mankind. But also the small world, the natural surroundings of man, were rediscovered. One looked at nature with different eyes. New inventories of vegetables and animals were taken; and investigation of the human body was a part of the great adventure, the discovery of the world. Once more men became aware of the beauty of the human body, and they endeavored to represent it in all its natural glory. If the medieval artists as a rule failed to represent the nude body with anatomical exactness, it was not because they had no chance to study it, but because their attitude towards the human body was different. In the Renaissance, the artist began to study the body by examining the ancient statues that were being excavated in ever-increasing numbers, and by observing nature. Botticelli's Venus was distinctly inspired by the Medician Venus that had been unearthed in his time. Some artists, however, were not satisfied with studies in plastic anatomy, but wanted to know the structure of the body under the skin. The prince of such investigators was Leonardo da Vinci.

When, in the eighties, the anatomical and scientific drawings of Leonardo were made available to the public through the publication of Richter, a great enthusiasm for Leonardo arose. His work was approached emotionally and uncritically, and he was considered the first real scientist of the Occidental world. Then followed the studies of Pierre Duhem on the physics of Leonardo, where for the first time his work was studied from a critical standpoint. In endless books, men tried to solve the riddle of his personality. Most of them made the mistake of measuring him on the wrong yardstick; Benedetto Croce from the point of view of speculative idealism, and Olschki from the point of view of modern positivism. Leonardo has to be studied as a man of the Renaissance; this has been done in an admirable way by Ernst Cassirer. Leonardo represents a type of amateur scientist. He never went through a university, he was an illegitimate child. He was a strong opposition to the

traditional scholastic science of the time, constantly making sharp distinctions between the discoverers and mere imitators. His work marks a shifting from books to the book of nature, from revelations in words to revelations in works. Mathematics to him formed the very heart of all knowledge. All knowledge was nothing more than a measuring, and everything was expressed in proportions. Proportion was the medium of recognition, and proportion was not only a logical and mathematical, but an æsthetic conception as well. This formed the link between the scientist Leonardo endeavoring to investigate nature, and the artist Leonardo, recreating nature in his work. Nature is the realm of perfect forms, and is ruled by necessity. The fact that Leonardo admitted to such a concept of natural laws made him a true scientist. Nature is dominated by reason. Experience and reason are not contradictions—they are two principles. Experience reaches its goal in mathematics, just as mathematics bears its fruits in experience.

Still, the study of man claims the first place in Leonardo's interest. Man is the primary object of his research. He studies the proportions of the human body, the plastic aspect of its outlines; but he goes further, stripping the skin, dissecting the body. Thousands of sketches are the result of his studies, which were intended for a complete book of anatomy that was to describe the structure of man from the very moment of his conception. Leonardo knew the medical literature of the day. Quite a few of his sketches are not the result of observation, but illustrate statements he had found in books. However, he was never satisfied merely with what he read, but always went further, approached the cadaver, experimenting, dissecting, making notes and drawings.

Leonardo's anatomical work was never finished, and after his death, his drawings were scattered to the winds. His whole life work, artistic and scientific, remained a torso, which is not to be wondered at, since it was an entire cosmos that he was attempting to recreate. Leonardo is a unique figure. A man of the Renaissance, to be sure, and yet hard to place in the category of his time. He was extremely interested in function, in dynamics, while sixteenth century science was essentially static; and it was only one hundred years later that dynamics were attacked by the scientist.

The doctors, too, were not idle. They, too, found themselves drawn to the study of the human body. Cadavers were now somewhat easier to obtain, and as early as the beginning of the sixteenth century we find quite an important group of anatomists who, although still convinced of the superiority of the ancients, performed a great many dissections themselves, and left good descriptions of certain organs: men like Alessandro Achillini in Bologna, who wrote *annotationes* to Mundinus; Gabriele Zerbi in Padua, Alessandro Benedetti; and most important of all, Berengario da Carpi, professor of surgery in Bologna, who also wrote a commentary to Mundinus, which contained some quite valuable observations.

The true founder of modern human anatomy, however, was Andreas Vesalius, a man who, from early childhood, had felt himself drawn to these studies. At the age of twenty-three, he was appointed professor of surgery and anatomy in Padua. Four months after his appointment he produced his first anatomical atlas, six plates illustrating the skeleton, and the arterial and venous systems.

What made his way clear was the discovery that ancient anatomy was essentially animal anatomy. He understood that the structure of the human body had never before been described completely and systematically, that the work still had to be done. Vesalius was lucky in having a very fine artist to assist him. At the age of twenty-seven he had accomplished a task that in other people would have represented the work of a lifetime. In the year 1543 the seven books *De Corporis Humani Fabrica* were published in Basel, a great work and a beautiful book, of 663 folio pages, with more than 300 illustrations. An Epitome for teaching purposes appeared simultaneously, and this Epitome was translated into German as a textbook for surgeons, by the rector of the University of Basel, Albanus Torinus.

Vesalius lived to the year 1564, but his work had been done long before that. He resigned from the University of Padua, and lived at the imperial court as a body-physician to the Emperor. The inspiration he had given was strong enough to spread enthusiasm for anatomical studies throughout the century. His chair in Padua was for a long time filled by people who continued to be the leaders in anatomical study; Realdo Colombo, well-known for his description of the pulmonary circulation; Gabriele Falloppio, whose *Observationes Anatomicæ* are noteworthy for their accuracy; Fabricius of Acquapendente, whose anatomical theatre can still be seen at the University of Padua, the teacher and inspiration of Harvey; Giulio Casserio, who wrote a classic book on the auditory organs. Outside Padua, in Bologna, Rome, Naples, and, towards the end of the century, north of the Alps, anatomy became a more and more important object of research.

Vesalius' book was published in 1543, the same year in which Copernicus' *De Revolutionibus Orbium Cælestium,* appeared. In laying the foundation of human anatomy, Vesalius laid the foundation of modern medicine. The year 1543, therefore, marks the beginning of a new era. From then on, anatomy was the iron fundament of medicine. But more than this, anatomy became a method of thinking. The history of medicine from Vesalius to our day is to a large extent the history of the application of anatomical methods. Step by step, one field after another was conquered by this new method. Physiology at the time of Vesalius was still speculative and philosophical in character. In the seventeenth century, anatomy developed into *anatomia animata,* and an anatomical physiology was born, working by means of experiments. In the eighteenth century, pathology became anatomical. A new ontological concept of disease had been realized, and disease from then on was attributed and bound to the organs. One saw that the symptoms of disease are the result of anatomic alterations in the organs. Diagnosis became diagnosis of the organs; percussion and auscultation were introduced as methods enabling the physician to observe anatomical changes. The last field that had to be conquered was therapy, which, down to the middle of the nineteenth century, still followed traditional lines. The final step was taken also, and found its expression in the development of modern surgery.

Today, this cycle has come to a certain conclusion; the anatomical method has been applied to all fields of medicine, and a new, a physiological era, has begun.

SCIENTIFIC THOUGHT AND SOCIAL RECONSTRUCTION*

C. E. KENNETH MEES

Director in Charge of Research and Development,
Eastman Kodak Company

Concerned as he was with the design and production of industrial machinery, Doctor Steinmetz realized that the increasing use of that machinery must have a profound effect on the social, economic, and political relations of men, and he was constantly speculating as to the future of our machine civilization. In commemorating his work, therefore, at this crisis in human affairs, it seems appropriate to turn for a short time from the consideration of technical scientific progress and to dwell on the reaction which that progress is having upon the life of mankind and upon the relation of the scientist to that reaction.

In the change which has recently come over our theories of the nature of the physical universe, nothing is more striking than our abandonment of the necessity for continuity in physical phenomena. We no longer insist on the representation of all phenomena by differential equations, and we are content to accept the view that many phenomena are essentially discontinuous in their nature. Discontinuous phenomena, however, often have their origins in continuous phenomena which are antecedent to them. For instance, the slow changes which occur in the earth's crust, involving the rise of one portion of the crust in relation to another, produce steadily increasing strains which are suddenly relieved by a slip which produces an earthquake.

In the same way, the steady changes in knowledge and technique which occur from time to time in human society produce a state of strain which can only be relieved by a transition period of rapid change. Such transition periods have often occurred in the history of the world, and there have been rapid changes both in relation to the material control which man has over his environment and also in relation to the economic and social structure of society. Frequently, these changes have been accompanied by great mass movements of peoples, resulting in the destruction of nations and the erection of new empires on the ashes of the old.

Between the fourteenth and the twelfth centuries B. C., a great change resulted in the destruction of the oldest stable empires of which we have any record. The origin of that change we do not know. It was quite possibly the culmination of climatic changes in the great plains of Eastern Europe and Western Asia. In the course of it, Crete lost her control of the northern Mediterranean and finally vanished from the list of the empires. The Achæan Greek civilization, which Crete had founded, disappeared in its turn. The Hittite Empire, attacked in the north, pressed through to the south, came into conflict with Egypt and finally with the new power of Assyria, and was destroyed. Assyria conquered Babylonia and expanded its new empire, which

* The eighth Steinmetz Memorial Lecture given annually at Union College under the auspices of the Schenectady section of the A.I.E.E.

was eventually to overrun Egypt itself. It was perhaps at that time that the predecessors of the Romans swept into Italy and that the great Celtic invasions of Britain and Gaul occurred.

In the fifth century after Christ, a similar rapid change in the organization of world power and consequently in the economic and social life of the civilized world took place. The Gothic invasion of Italy, with the transfer of the empire from Rome to Constantinople, terminated the domination of the western world by Rome.

In the fifteenth century again feudalism came to its end, and the social system which had ruled the world for a thousand years deliquesced and changed before the eyes of man. At the same time, Northern Europe largely abandoned its traditional religion and established a new church, which carried with it altogether new and different social relations.

Portentous as these changes were, and rapid as they seemed at the time, they were, nevertheless, extremely slow in comparison with the changes which we have seen and which we are now witnessing. The two earlier changes which I have mentioned took several centuries to accomplish, and even the more rapid change at the close of the Middle Ages took more than a hundred years to complete. Compared with any of these, the great industrial revolution of the nineteenth century, when machinery and factory organization took the place of hand labor and the home industry, was extremely rapid, but that whole century saw less change in the life of man than the first third of the twentieth. Within our own lifetimes we have seen changes in method and technique which will affect the economic and social organizations of society to perhaps as great an extent as the whole of the changes which have occurred from the Neolithic period to the beginning of the twentieth century.

At the present time, the rate of change is greater than any in the previous experience of man, and it appears to be still accelerating. The origin of this change is, of course, the development of our knowledge of nature, that knowledge which we classify under the general heading of "science," and so long as our increase in scientific knowledge continues to accelerate, the resulting change in social and economic conditions will also accelerate. At the present time, the proportion of human effort devoted to the acquisition of new scientific knowledge is increasing each year, but it is still only an infinitesimal part of the activities of mankind and only a very small part of the amount of energy which might be expended upon the development of science if that were generally thought to be worth while.

The production of scientific knowledge causes changes of great importance in our economic and social life, and the changes lag very much behind the production of science, so that as a general rule the science which is being applied today is not the science which is produced today but the science of which the fundamentals were discovered a number of years ago. As the rate of production increases, the period between a scientific discovery and its application diminishes, and whereas it took us fifty years to apply Faraday's discovery of electromagnetic induction, such discoveries as the amplifier tube have been applied on a world-wide scale within two decades; and at the present time we

might be considered as applying generally scientific discoveries of only ten years ago. The much greater production of scientific knowledge at the present time, however, means that the application of science to industry and, still more, its effects on our economic and social life will continue to increase even if the amount of scientific discovery in the near future does not, and there is every probability that that also will continue to increase.

This rapid change which is going on in human affairs, having the curious characteristic that it is continuously increasing in rate, may be compared to an autocatalytic reaction in chemistry. An autocatalytic reaction is one in which a product of the reaction increases its rate, so that if you put all the materials into a vessel and start the reaction going, it will begin slowly and then increase in rate and go faster and faster as the products accumulate. Such a reaction ends in a complete conversion of the system into a new form. Sometimes, the rate increases so much that the reaction becomes explosive and the new form is entirely different from the original system. Sometimes, after a period of violent reaction, the system settles down into a new and stable form. No system which is changing at an increasing rate, and especially no system in which the product of the reaction increases the rate of change, can be stable.

In our present system, it seems that the very scientific knowledge which is produced tends to increase the rate of change, and it is therefore probable by analogy, although it is not at all certain, that our social system is in an unstable stage and that after a period of rapid change it will settle into a new and stable phase which will endure until some new cause provokes another period of change. What that system may be and how it can be stabilized, since we must assume that scientific discovery will continue, it is impossible for us to foresee, but it is certain that change cannot continue to occur at an ever-increasing rate.

During the period of activity in which we find ourselves at the present time, many experiments are being conducted; new social systems are being evolved, and new economic methods are being tried. The corporate state under a Fascist dictatorship and the corporate state under a Communist dictatorship are only two of the more striking experiments which are being conducted at the present time, with mankind at large as the subject of the experiment and with the happiness and lives of mankind dependent upon the success of the experiments.

It is clear that scientific men cannot stand aside from these vast political and social experiments and ignore them, restricting themselves merely to protests, when such experiments are likely to affect their personal interests. The conditions which necessitated adjustments and changes in the social order arose from the growth of science, and scientific men must feel that they have an especial responsibility for the correct orientation of the social system towards those conditions. Moreover, there is a technique of experiment and that technique must be learned. It is not a natural gift of mankind. Anyone who has watched experiments carried out by men untrained in the methods of science will know how costly and wasteful such experiments are likely to be, and if social reconstruction is to be undertaken as a series of vast experiments, it is,

at any rate, desirable that those who conduct the experiments should have been trained in the technique of experimentation. It was this which led Prof. Miles Walker in his address to the Engineering Section of the British Association in 1932 to call on the engineers to manage the world. He felt that if the engineers —in which term for brevity he included all scientific men—took a greater part in world management, they would make a greater success of it. He suggested that actual experiments in the form of self-supporting colonies consisting of groups of a hundred thousand people should be formed under the auspices of engineers and economists. More recently, Sir Frederick Gowland Hopkins in his presidential address to the British Association at Leicester this year reminds us of the indictment that the command of nature has been put into man's hands before he knows how to command himself, but he suggests that this is an indictment of mankind and not an indictment of science.

To me, however, an indictment of mankind seems quite useless. If we cannot indict a nation, how can we indict a species? We must play the game with the cards that are dealt; we must reconstruct society with men as they are. We must assume the probable behavior of mankind as we assume the properties of any other material which we have to use, and we must find our solution on the assumption that that behavior will continue.

The scientist, then, as I see it, cannot retire into his shell. Nor do I agree with Professor Walker that it would be wise for the scientist to attempt to take up the burdens of the politician or the statesman. It is imperative that he should continue to carry out his own work, from which may come the salvation of mankind. The especial work of the scientist is the creation of ordered knowledge, which is then available for use by all mankind. But in this especial work he employs a special method and he approaches his problems in a special spirit, and this method and spirit constitute, I believe, the chief contribution of science towards social reconstruction.

In the last twenty years, a great change has come over the technical industries of the world and especially of this country. That has been ascribed, probably with justice, to the great expansion of industrial scientific research. But I do not believe that it is the actual work done in the industrial research laboratories which has produced the change; it is, rather, the growth of the scientific spirit in all sections of the industrial organization. The executives of modern technical industry have been trained in the methods of science and face their problems with a scientific attitude. In order that the scientific spirit should be used in government, it is not necessary or even desirable that professional scientific men should abandon their laboratories and attempt to deal with executive problems, but it is necessary that they should expound insistently the nature of scientific thought and study its application to our social and political problems.

Once before in history, the application of scientific methods to the theory and practice of government was almost realized. In the Golden Age of Greece, the great group of philosophers, of whom the most perfect expression was to be found in the work of Aristotle, had made a truly scientific approach to the problems of nature. Then, the destruction of the philosophic spirit during the

period which followed the wars of Alexander, the rise of the materialistic military empire of Rome, and finally the destruction of almost all the culture of the old world, with the downfall of the classical pagan religion, brought the advance of scientific thought to an abrupt end.

Throughout the Middle Ages, the authority of the written word almost completely displaced first-hand observation and experiment in the search for truth. The revolt against authority arose in the early sixteenth century; Galileo and Kepler in astronomy, Gilbert in electricity, and Harvey in physiology, made great contributions to scientific knowledge. Francis Bacon, nobleman, politician, and lawyer, while himself not practiced in experimental methods and while ignorant apparently of the great work of his contemporaries, had a wonderful gift in his trenchant pen and his facility of expression, and he carried the popular imagination with him in his emphasis on observation and experiment as against blind acceptance of the written word. The following passage accredited to him illustrates admirably the irony and sarcasm he could use to emphasize his contentions:

> "In the year of our Lord 1432, there arose a grievous quarrel among the brethren over the number of teeth in the mouth of a horse. For thirteen days the disputation raged without ceasing. All the ancient books and chronicles were fetched out, and wonderful and ponderous erudition, such as was never before heard of in this region, was made manifest. At the beginning of the fourteenth day, a youthful friar of goodly bearing asked his learned superiors for permission to add a word, and straightway, to the wonderment of the disputants, whose deep wisdom he sore vexed, he beseeched them to unbend in a manner coarse and unheard-of, and to look in the open mouth of a horse and find answer to their questionings. At this, their dignity being grievously hurt, they waxed exceedingly wroth; and, joining in a mighty uproar, they flew upon him and smote him hip and thigh, and cast him out forthwith. For, said they, surely Satan hath tempted this bold neophyte to declare unholy and unheard-of ways of finding truth contrary to all the teachings of the fathers. After many days more of grievous strife the dove of peace sat on the assembly, and they as one man, declaring the problem to be an everlasting mystery because of a grievous dearth of historical and theological evidence thereof, so ordered the same writ down."

Bacon put exclusive emphasis upon the inductive method; that is, direct observation of nature and inferences drawn therefrom as against the written words of the past.

In the year of Bacon's death, 1626, a Frenchman, who some years before had left the army because of his interest in philosophy, returned to Paris to begin the definite study of mathematics as the basis of a system of philosophy, and eleven years afterwards Descartes published a system of coordinate geometry which, for the first time, linked together the old mathematical sciences of geometry and algebra. In Descartes' philosophy of science, he emphasized

the development of theories obtained intuitively and the deduction of conclusions from those theories.

For many years the two methods—the inductive method of Bacon based on pure experiment and the deductive method of Descartes based on intuitive reasoning—have found themselves opposed to each other. Even today it is common for philosophers to discuss the relative value of inductive and deductive methods, but it seems to me that such discussion is like an argument as to which part of the body is most important to a man. Does he need most his head, his heart, or his intestinal tract? The answer is, of course, that he needs them all; he cannot live without them. To find out something about nature, we need facts, first of all; secondly, a linking idea which will enable us to get into one picture all the facts that we are considering. This linking idea we call a hypothesis; then, from the hypothesis we deduce consequences. These consequences must follow from the hypothesis and they must also be of the type which we can verify. It is of no use to deduce consequences which it is impossible for us to verify when we are searching for evidence as to the validity of a hypothesis. If all the consequences which we can deduce and all the facts which we can find fit the picture which we form, then we term that picture a theory and grant it validity until we meet well-attested facts which will not fit it.

It will be seen that the scientific method involves both the inductive method of Bacon and the deductive method of Descartes. Bacon laid the greater stress on the experimental work leading to the facts which a hypothesis was formed to fit; Descartes laid the greater stress upon the intellectual leap by which a hypothesis was invented to fit the facts, but both are necessary. We must get the facts by experiment, and we must deduce a hypothesis by instinct. A great experimenter will perhaps accumulate many facts before finding a fitting hypothesis. A great thinker may leap intuitively to a hypothesis before he has many facts. In the one case, the experimenter must search for his hypothesis; in the other, the thinker must find an experimenter to supply him with the facts. Sometimes the completed theory must be abandoned because facts are found which are quite incompatible with the theory, and it is necessary to construct an entirely new picture, while at other times, and perhaps more generally, a theory may have to be modified or extended in detail as new facts become available.

The fundamental purpose of scientific research is to make an orderly picture of nature, so that we can understand it and thus be able to predict for ourselves without actually determining all the facts directly.

The following is perhaps a rough picture of the way in which man has proceeded in his conquest of nature. Suppose that a man entered the door of a vast room which was a storehouse of information—a library, in fact—but suppose that instead of books each fact or statement was written on a piece of paper and that these pieces of paper, of all sizes and kinds and written in all languages, were piled up higgledy-piggledy to the ceiling; and, moreover, suppose that the room was unlimited in size. The first impulse of a man entering such a room would be to go away, but the man I am speaking of is the human race, and the difference between the human race and other animals is that it did not go away; it set to work to sort the facts. Very, very slowly at first,

but faster later, as it gained experience, the human race started to sort out that library of facts and to place together the facts that seemed to be of the same kind, so that they could be classified. At first, when man took up a slip of paper and read it, it meant nothing to him because he had never seen the same fact before, and so he put it down and went on to the next; but presently he began to put them together and regard them as in the same classification or, as he put it, due to the same cause. Quite often man was wrong in this belief and his associations have persisted through the ages. When such incorrect associations have been held by many men for many years, we call them "superstitions," and they become so rooted in our minds that they are very hard to eradicate.

Perhaps the most interesting systems of incorrect association of facts are those which are known as *magic* and *religion*. One of the earliest facts of which an animal becomes conscious is that its own body is not functioning normally. Usually the trouble corrects itself and the animal recovers. As soon as man began to reason, he must have tried to find remedies for his bodily disorders, and those remedies would be associated with his daily routine and especially perhaps with food. If a plant can make you ill, cannot the same plant or another make you well? When primitive man ate the same plant, he was using a homeopathic medicine; when a different plant, an allopathic medicine. When he simply hung the plant around his neck, he was employing magic. Among primitive peoples, magic has always played a great part, and it is perhaps a little difficult for us to realize how deeply the principles of magic are entrenched in the thought and history of man. Frazer analyzes into two the principles on which magic is based: First, that like produces like or that an effect resembles its cause; and, second, that things which have once been in contact with each other continue to act on each other at a distance. From the first of these principles, which he calls the "law of similarity," is inferred that a man can produce any effect he desires merely by imitating it, so that if a savage, for instance, wants a good crop, he will take care to have it sown by a woman who has many children or, if a witch doctor wants to hurt a man, he will make an image of him and then destroy it in the belief that, just as the image suffers, so does the man, and when it perishes, he must die. From the second principle, it is inferred that whatever is done to a material object will affect any person with whom the object was once in contact, so that most savages are very careful to burn any hair they cut off or the parings of their nails lest an enemy might use them to do them harm; and in some African tribes, anything once touched by the king must be carefully destroyed. The negative principle corresponding to the principle of similarity is the great, widespread law of taboo, which governs the things which a man abstains from doing lest, on the principle that like produces like, they should spoil his luck. The Eskimo boys, for instance, are forbidden to play cat's-cradle because, if they do so, their fingers might in later life become tangled in the harpoon line. The principles of magic are so widespread that almost all the lives of primitive peoples have some relation either towards acts intended to produce luck or towards things refrained from lest they might produce ill luck. These wide-

spread roots are by no means extinct among us today, so that on careful analysis many of our beliefs will be found to be essentially magical in origin although we are generally no longer conscious of the sources from which those beliefs have sprung.

An even greater factor than magic in the history of man has been the development of religion. Very early, man observed that his food and well-being were closely connected with natural phenomena, such as the cycle of the seasons, which we know to be due to the movement of the earth around the sun. He, however, catalogued the facts that he knew under the hypothesis that natural phenomena were due to the operation of intelligent beings made in his image and gave these invented beings jurisdiction over groups of natural phenomena, so that there were gods of the earth, the sky, the sea, and minor gods of trees, rivers, and mountains. Sometimes psychological facts were classified in the same way, and there were gods of love and war, or terror and sorrow, and thus was built up the structure of religion. When the great prophets came—Buddha, Jesus, and Mohammed—their philosophy drew on this structure, and their followers incorporated much of the earlier religious belief in the systems of philosophy which were founded on their teaching, so that today, in the vast mass of what we term "religious beliefs," we come continually on groups of associations which started as hypotheses to be used in the classification of natural phenomena. Many Christian hymns still repeat the belief that the crash of sound which follows the discharge of electricity from a cloud is the voice of a god.

Unquestionably, the development of magic and religion as pseudo-sciences, which provided systematic classifications of phenomena, tended to retard the development of scientific thought, but this was probably not so much because the classifications which they provided were incorrect as because of their attitude towards the method by which such classifications should be made. From the beginning, the insistent note was heard from priests and prophets that it was the duty of their followers to have faith, to accept and to follow authority.

Now, the acceptance of authority is the very antithesis of the scientific method of thought. Step by step, man has established his claim to deal with phenomena directly, without the acceptance of any authority. But there are not lacking signs that today this claim is being challenged and challenged sharply. The troubled time through which we are passing has enabled men to seize authority who have no desire that independent decisions shall be made by those whom they rule and who believe (in most cases, sincerely) that rule by authority is necessary. In Italy, in Germany, in Russia today authority is the only voice to be heard. It may appear that this has no relation to technical science, that the suppression of adverse political opinions has no importance for the future of engineering. But science is all one, its method and its spirit are one, and the age-old foe of that method and that spirit is authority.

There are certain characteristics of scientific thought in which it is distinguished very sharply from many other methods of thought. I have already dealt with its neglect of authority as such and with its direct appeal to experiment and to the classification of demonstrated facts. But in the political sphere,

and, I am afraid, in the spheres of sociology and economics, the absence of emotion, which is characteristic of scientific thought, is an even more striking distinction. In most political matters we don't think, we feel. Some years ago, I reminded a friend of mine who was praising a certain national statesman that though he might be, as my friend claimed, the wisest and noblest of mankind, he was yet a man and not a god; and when a few years later my friend had changed his political views, I had to remind him that that statesman might be the vilest and basest of mankind, but he was a man and not a devil.

The following quotation from Bertrand Russell's "Skeptical Essays" seems to me to express better than I could the difference in methods of thought:

> "We have had in recent years a brilliant example of the scientific temper of mind in the theory of relativity and its inception by the world. Einstein, a German-Swiss-Jew pacifist, was appointed to a research professorship by the German government in the early days of the war; his predictions were verified by an English expedition which observed the eclipse of 1919, very soon after the Armistice. His theory upsets the whole theoretical framework of traditional physics; it is almost as damaging to orthodox dynamics as Darwin was to Genesis. Yet physicists everywhere have shown complete readiness to accept his theory as soon as it appeared that the evidence was in its favor. But none of them, least of all Einstein himself, would claim that he had said the last word. He has not built a monument of infallible dogma to stand for all time. There are difficulties he cannot solve; his doctrines will have to be modified in their turn as they have modified Newton's. This critical undogmatic receptiveness is the true attitude of science.
>
> "What would have happened if Einstein had advanced something equally new in the sphere of religion or politics? English people would have found elements of Prussianism in his theory; anti-Semites would have regarded it as a Zionist plot; nationalists in all countries would have found it, tainted it with lily-livered pacificism, and proclaimed it a mere dodge for escaping military service."

In the brilliantly written introduction to that book, Russell points out that the amount of emotion which is felt by any thinker upon a subject is a measure of his uncertainty with regard to that subject. A denial that the logarithm of 2 is .30103 arouses absolutely no anger in any breast. When a politician declares in a court of law that he doesn't believe that man is a mammal, no sense of indignation arises; it is the risible faculties only which are stirred. But when we become less certain, we become more emotional. An attack on one's personal character may easily stir one to anger because of internal doubts as to whether that character is unassailable; while the wild enthusiasm with which a nation will undertake to destroy another nation is a measure of the complete ignorance which exists as to the nature of the matter at issue. It is very unfortunate that into recent discussions of social reconstruction and of economics a large amount of emotion has entered, so that it becomes of greater importance to consider the attitude of the Russian government towards religion

or towards marriage than to study dispassionately the possible success of the gigantic economic and social experiment in which they are engaged; or to criticize the relations of statesmen to certain bankers who stand as symbols, than to discuss whether or not their views on finance are correct.

We are often told nowadays that our economic system has failed and that the individualistic control of production and distribution must be replaced by another more centralized system. No engineer will object to better planning, but it is essential that before we adopt a new system of industry on a nation-wide scale, we should have reason to believe that it is a better system. Now, the atmosphere in which the existing discussion of economics and sociology is being carried on is singularly unsuited to such a discussion. There is a story of a preacher who lost his place in his sermon when Henry Ward Beecher was in the congregation. He afterwards asked his distinguished colleague what he did when he found himself in a similar difficulty. "Oh," said Beecher, "I do what you did; I yell." At the present time some bureaucrats and politicians seem to meet difficulties by yelling.

Unfortunately, so long as men's actions are controlled by their emotions, an objective thinker who discussed every proposition without emotion would have no part in modern political life, since a politician must understand the effect of emotional thought and must be prepared to utilize emotional appeal if he is to obtain popular support. A successful political leader must tend therefore either to believe his own emotional appeal or to become a cynic and to some extent a hypocrite if he exerts that appeal without belief. It is this difficulty which makes even the greatest democratic leaders seem insincere in many of their actions; the appeal to emotion is unavoidable if popular sanction is to be obtained, and yet their critics and often they themselves in retrospect feel that appeal to be false and unwarranted. It seems to me that for this reason alone the political arena is unsuitable for the scientific man and that those who believe most fully in the value of the scientific spirit should be prepared to understand and sympathize with leaders who must obtain general popular approval for their actions.

The cleavage in intellectual outlook and mental habits between the political leader and the scientist, the engineer, or, for that matter, the industrialist, is a very real and fundamental one and is by no means to be dismissed summarily. It is common for scientists and industrialists to discuss the methods of the politician as if they were either merely stupid or deliberately wicked, while the views of the political expert as to the "intellectuals" are often scornful in the extreme. In practice, the adoption of political methods controlled by pure reason could only succeed if they accompanied a dictatorship and the rule of the majority of the people by a small minority. Dictatorships, whether fascist or communist, can be far more objective and direct in their methods than can democracies. This does not mean that dictators are necessarily, or even probably, exponents of the scientific spirit; indeed, their constant appeal to *ex-cathedra* authority is essentially unscientific, but it does mean that the leaders of a democracy cannot be truly scientific in their attitude and that scientific men must choose between the path of pure reason, which leads directly to

oligarchy, and democracy, which involves a certain amount of compromise and confusion.

In 1916, Doctor Steinmetz published a brief paper entitled "Industrial Efficiency and Political Waste,"[1] in which he warned us of the necessity for a change in our political system, taking as a model the efficiency of our great industrial organizations. This change he felt was necessary because "The economic development of the world, accelerated by the World War," has made a cooperative industrial organization of our nation a necessity for self-preservation. "Such a cooperative industrial organization," said Steinmetz, "presupposes a powerful, centralized government of competent men remaining continuously in office." Doctor Steinmetz felt that such a political change, however desirable, was unlikely to occur since it was incompatible with the democratic temperament of the American people.

If the democratic system of government cannot change to meet the requirements of the changing world system, it must inevitably give way to other systems. That this is so is the claim of many leaders of political thought and, notably, of Mussolini. But only a few years ago it seemed impossible that industry should ever be organized to use scientific methods. The industries of the last century were, with few exceptions, utterly remote from the methods of thought current in the laboratories of the universities and were controlled largely by "self-made" autocrats. Within our lifetimes all that has changed and the leaders of our modern industries are often technically trained experts, completely removed from their predecessors as to their outlook and habits of thought.

In order to attain a similar result in the field of politics, we need no revolution; we require only an orderly evolution of the same type. As Janssen says, "There are very few difficulties which cannot be surmounted by a will strong enough or by study sufficiently profound." It is not at all impossible that in a few years the political demagogue may be as rare as the industrial autocrat has become. In order to achieve this result, we must improve the methods of thinking of the public, so that they will select suitable governors and then will require from them real leadership and accurate thought. It is both our duty and our right to select for ourselves those who govern us, and the necessary changes can be effected by the proper exercise of that duty and right. The art of government is exceedingly difficult, and it is of the utmost importance, especially in such times of transition as the present, that the men chosen as administrators should be selected with the utmost care.

The selection of the best methods of procedure in government, as in science, depends eventually upon judgment, and judgment depends upon the natural capacity of the judge and upon his training and experience. It should be accepted that in any judgment there will be error, and that errors will occur in accordance with the laws of probability. The judgment will be better as the probable error is smaller, but there will always be some error. The administrator, moreover, will suffer from bias. If he is sufficiently objective in mind and sufficiently experienced, he will recognize that and will attempt to make a

[1] Harpers Magazine, 133, p. 925, 1916.

correction for it just as we correct precision measurements for the "personal equation." We should, therefore, so select our methods of government that there is a maximum chance of arriving at the best judgment, a minimum opportunity for bias, and a probability that the best judgment that can be arrived at will be applied.

Insofar as our present methods do not meet these requirements, they should be changed, but the most important matter is that we must be prepared to seek out specifically for the functions of government the best men that we have, not necessarily the best in quality but often the best in character, since a man might have first-class judgment and yet be so biased by his ambitions that his decisions would be affected.

In addition to selecting the most suitable leaders, however, the public must be willing to accept their leadership, to value the expression of intelligent thought, and to discount all appeals to emotion and to sectional interests. In order that we may assist in the attainment of this result, it is the duty of scientific men everywhere to insist on the value of the scientific spirit and method of thought.

My plea today, therefore, is that we should deal with the problems of social reconstruction as we do with all other problems. Let us accept and consider all proposals, of whatever kind, for a better method of operation. Let us refuse absolutely to accept authority as such; let us ignore emotional appeals; and let us pin our faith to those methods of reasoning which have proved so successful in the analyses of all types of natural phenomena.

The scientific method of thought is not applicable only to one class of phenomenon nor is its use confined in any way to those who have been specifically trained in technical science. The scientific habit of mind and the scientific spirit should be understood and cultivated by the community as a whole.

I think that all of us must desire that we could honestly say of ourselves, as Francis Bacon felt justified in saying:

> "For myself I found that I was fitted for nothing so well as for the study of Truth; as having a mind nimble and versatile enough to catch the resemblance of things (which is the chief point), and at the same time steady enough to fix and distinguish their subtler differences; as being by nature with desire to seek, patience to doubt, fondness to meditate, slowness to assert, readiness to reconsider, carefulness to dispose and set in order; and as being a man that neither affects what is new nor admires what is old, and that hates every kind of imposture. So I thought my nature had a kind of familiarity and relationship with Truth."

Rochester, New York, January 9, 1934.

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF SIGMA XI, BOSTON

December 28, 1933.

The second meeting of the Executive Committee for 1933 was held in Parlor A, Statler Hotel, Boston, December 28, 1933. The meeting was called to order at 2.00 P.M. by President Wilson. Those present were: President Wilson, Secretary Ellery, Treasurer Pegram, Professor Lloyd; and by invitation, Dean Richtmyer of Cornell, Prof. Kirtley Mather of Harvard, and Professor Cartledge of Buffalo.

1. FORM OF FORMAL PETITIONS FOR CHARTERS FOR CHAPTERS:

The question of whether a formal petition for a charter for a chapter should be printed or whether some other form would be acceptable was presented and discussed. It was

Voted—That petitions for charters for chapters could be prepared by zincograph or other reproductive process, provided a high quality of neatness, typography and durability is preserved.

2. PETITION FROM TULANE UNIVERSITY:

The Secretary referred to the action taken by the committee at the meeting in Chicago, June 21, 1932, inviting the group of petitioners at Tulane University to present a formal petition at the December meeting, and reported that the petition in proper form had been prepared. It was

Voted—That the formal petition from the group of petitioners at Tulane University should be presented to the convention with recommendation for favorable action.

3. PETITION FROM THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY:

The Secretary reported that in accordance with the action of the Committee at the June meeting in Chicago, a group of petitioners at the Massachusetts Institute of Technology had prepared a formal petition for a charter for a chapter. It was

Voted—That the formal petition from the group of petitioners at the Massachusetts Institute of Technology should be presented to the convention with recommendation for favorable action.

4. WESLEYAN UNIVERSITY:

In accordance with previous action of the Executive Committee, the Secretary had sought the opinion of deans of graduate schools in institutions neighboring to Wesleyan, and of heads of science departments in those institutions, about the quality of the scientific work done at Wesleyan. Letters were presented from President Conant of Harvard, the deans of the graduate schools

at Harvard and Yale, and Prof. L. C. Dunn of Columbia. These letters commented favorably on the quality of the work done by graduate students in those universities who had had their preparation at Wesleyan. It was

Voted—That official visitors be appointed to make personal survey of the resources and equipment at Wesleyan, and to confer with the administration and heads of science departments.

President Wilson appointed Professor Pegram (Columbia) and Professor Baitsell (Yale) as such visitors.

5. UNIVERSITY OF BUFFALO:

Prof. G. H. Cartledge, head of the department of chemistry at the University of Buffalo, presented additional information about the resources of the university and the research work in progress in various departments.

Dean Richtmyer (Cornell) and Professor Wilkins (Rochester), who had been asked by the Committee to present opinions regarding the scientific work of the university, responded to the request, Dean Richtmyer by letter and in person. It was

Voted—That the situation at the University of Buffalo be given further consideration either at the spring meeting or the December meeting of the Committee.

6. SMITH COLLEGE:

Prof. Kirtley F. Mather (Harvard) and Prof. L. C. Dunn (Columbia), who had been appointed by President Wilson as official visitors to Smith College, submitted their report, together with recent official bulletins published by the college. (Professor Mather presented the report in person.)

THE EXECUTIVE COMMITTEE,
THE SOCIETY OF SIGMA XI:

Gentlemen: We have spent a day at Smith College and one of us has subsequently had an extended conference with President Neilson. We wish therefore to submit at this time our report concerning the request that a chapter of the Society of Sigma Xi be established at Smith College.

Recognizing the fact that this request involves the important matter of policy pertaining to the activities of Sigma Xi in women's colleges, we prefer not to make any definite recommendation either of approval or disapproval of the application from Smith. It is, however, our opinion that the physical equipment and intellectual activity at Smith College leaves no grounds for discriminating against it because it is a woman's college. Indeed, Smith College is superior in these respects to many institutions which bear the name of university and open their doors to both men and women. With respect to the qualifications for a chapter of the Society of Sigma Xi, Smith stands at or near the head of the list of women's colleges.

Smith College was established in 1875. For several years past it has had an enrollment of two thousand undergraduates, the number set as the limit for

such enrollment. The School for Social Work is an important professional school which enrolls annually approximately 110 candidates for the degree of Master of Social Science. The Graduate School of Arts and Sciences has an enrollment of slightly more than 100 students, most of whom are candidates for the degree of Master of Arts. That degree is granted to thirty to forty-five candidates each year, of whom slightly less than half have usually taken their major work in some field of natural science. The degree of Doctor of Philosophy is occasionally conferred by Smith, but the policy is to provide sound training for the master's degree and to send the graduate student elsewhere for the completion of her training for the doctorate.

Smith College has a total endowment, according to the treasurer's report for June 30, 1933, of $6,192,705.77. On that date the value of the campus with its buildings and equipment was stated to be $7,934,255.68. The budget for the year ending June 30, 1933, shows expenditures of $2,232,281.37. The salary scale is as follows: Professors $3,600-5,500, associate professors $3,000-4,000, assistant professors $2,000-3,000, instructors $1,000-2,500. In former years the retiring allowance for Smith College teachers was provided by the Carnegie System. With the breakdown of that system the trustees arranged to provide a minimum of $2,000 per year as the retiring allowance for those who had been eligible for Carnegie pensions. All other members of the faculty, and this includes, of course, all those appointed during recent years, contribute 5 percent of their salary and the College contributes an equal amount toward the purchase of an annuity through the Teacher's Annuity and Insurance Company. Several years ago President Neilson arranged to have the teaching schedule reduced to an average of nine hours per week so as to give time for research. The only portion of the endowment funds which is definitely earmarked for research is that which supports the W. A. Neilson Research Professorship. This chair was occupied for five years, until 1932, by Dr. Kurt Koffka, who established the Laboratory of Experimental Psychology. The research chair is now occupied by a professor of comparative literature and Doctor Koffka is continuing as a member of the faculty on a half-time teaching and half-time research basis. It is planned in general to have the incumbent of the Neilson Research Professorship occupy that position for only one or two years at a time in order that more fields may be represented during a long term of years. Eleven fellowships are available for students in the Graduate School of Arts and Sciences, which cover all expenses in that School. In addition there are four graduate scholarships and four non-resident fellowships, one of which is restricted for use in the Department of Zoology. The undergraduates are required to complete satisfactorily two-year courses in science as a prerequisite for the bachelor's degree.

The laboratory equipment in chemistry, physics, psychology, botany, zoology, and geology is admirably qualified for carrying on both instruction and research. The laboratories used for work in these sciences compare favorably with those in the majority of the universities at which chapters of Sigma Xi are now in existence.

The administration of Smith College, as represented by President Neilson and Dean Nicholson, is apparently very deeply impressed with the value of research in general and the wisdom of fostering research at Smith College. Both President Neilson and Dean Nicholson expressed a strong desire for the establishment of a chapter of Sigma Xi at Smith. Several of the professors in the scientific departments reported to us that whenever funds were necessary for scientific apparatus for research or for the publication of the results of scientific research, they had had no difficulty in securing appropriations through the president's office.

A surprisingly large number of members of the faculty at Smith College is very active in scientific research. The Departments of Chemistry, Zoology, Physics, Psychology, Geology, Botany, and Astronomy are sources of valuable contributions to the literature of science which are frequently made by members of the staff ranging in rank from full professors to temporary assistants. The president's report for December, 1932, submitted herewith, lists on pages 54-67 the publications of the faculty from September 1, 1931, to September 1, 1932. This year is doubtless a fair sample for recent years. The list contains several notable contributions from Doctor Anslo and Doctor Jones in physics, Doctor Cann, Doctor Ayers, and Doctor Foster in chemistry, Doctor Koffka, Doctor Gibson, and Doctor Taylor in psychology, Doctor Grant in zoology, Mr. Meyerhoff in geology, and Miss Williams in astronomy. In general it may be stated that the scientific departments offer very satisfactory opportunity for a limited amount of graduate research in addition to the facilities for instruction to the level of the master's degree. Probably the equipment is now fully adequate for whatever research may be undertaken by the members of the staff or part-time assistants.

In answer to the specific questions which have been directod toward us, we would state:

(1) If a chapter of Sigma Xi is established at Smith College, it will doubtless stimulate an increased interest in research on the part of the faculty and student body, making possible a definite recognition of superior ability in this line. It will further direct attention to the excellence of the personnel and physical equipment for research which that institution possesses. This will doubtless make it easier for the administration to expand and further develop research activities of the institution.

(2) It would be to the advantage of the Society of Sigma Xi to assist thus in the promotion of research in an institution of superior qualifications. It would also be an advantage to demonstrate in this unmistakable way the fact that there is both opportunity and honor for women in scientific research.

(3) The present petitioning group includes twenty-four members of the Society of Sigma Xi. There is no question but that it will be followed by a similar group which would maintain the chapter on a high level.

Respectfully submitted,

KIRTLEY F. MATHER,
LESLIE C. DUNN.

After considerable discussion, it was

Voted—To ask Professor Mather and Secretary Ellery to ascertain what would be the probable effect on the Science Club already functioning successfully at Smith when and if a chapter of Sigma Xi were established, and to report at the spring meeting of the Committee.

7. UNIVERSITY OF DENVER:

The Committee was of the opinion that further consideration of the situation at the University of Denver should wait upon a report from Professor Leuschner, who is expected to visit the university before the spring meeting of the Committee.

8. UNIVERSITY OF FLORIDA:

Professor Pegram and Secretary Ellery presented recent information about the science work at the University of Florida. Owing to limited time available for discussion, it was

Voted—To make the recent and additional information about the University of Florida a special order of business at the spring meeting of the Committee.

9. TREASURER'S REPORT:

Treasurer Pegram presented a tentative report of receipts and disbursements for 1933 and stated that the final report would be ready for auditing at the close of the calendar year. The Committee

Voted—To present to the Convention the following resolution with recommendation for favorable action:

Resolved: That the annual assessment on each chapter for 1934 shall be payable on January 1, 1934, and that the amount of the assessment on each chapter shall be 75 cents multiplied by the number of members and associates of the chapter on January 1, 1934.

Resolved Further: That in sending notice of the 1934 assessment to chapter treasurers, the Treasurer of the Society be instructed to advise each chapter that the assessment is to be computed strictly on the basis of the number of members and associates on the membership roll of the chapter, without regard to whether said members have or have not paid current chapter dues, and to explain that this method of fixing the amount of the assessment on each chapter has been adopted by the conventions of the Society as the most equitable to all chapters.

10. CLERICAL ASSISTANCE TO THE SECRETARY:

Owing to temporary conditions in the office of the National Secretary, it was

Voted—To carry over to the calendar year 1934 any unexpended balance of the budget item for clerical service in the Secretary's office.

11. Finances in Illinois and District of Columbia Chapters:

Letters were presented from the treasurers of the Illinois and District of Columbia Chapters, stating that chapter funds were tied up in banks which had not opened after the national bank holiday, and asking for suggestions from the national officers regarding the financial obligations of the chapters to the national organization. It was

Voted—That the National Treasurer be authorized to extend the time of payments due from the Illinois and District of Columbia Chapters to such date as in his judgment the conditions warrant.

12. Items Postponed to the Spring Meeting:

Owing to lack of time for adequate consideration at this meeting, it was

Voted—To make the following special topics of discussion and action at the spring meeting:

a. Sigma Xi Clubs and Alumni Chapters.
b. The Semi-centennial Program.
c. Sigma Xi Insignia for Canadian Members.
d. Inquiry from Lowell Textile Institute.

13. Adjournment:

The meeting adjourned at 4.00 P.M.

Edward Ellery, *Secretary.*

PROCEEDINGS OF THE THIRTY-FOURTH CONVENTION OF THE SIGMA XI

The Thirty-fourth Convention of the Society of the Sigma Xi was held in Parlor A of the Statler Hotel, Boston, Massachusetts, December 28, 1933.

1. CALL TO ORDER:

The business session was called to order at 4.00 P.M. by President Wilson.

2. COMMITTEE ON CREDENTIALS:

President Wilson announced the Committee on Credentials as follows:
Prof. Frank Studer, Union, Chairman,
Prof. George LaRue, Michigan,
Prof. A. L. Fitch, Maine.

3. REPORT OF COMMITTEE ON CREDENTIALS:

The Committee received the credentials of the delegates, and reported that thirty-four chapters and six clubs were represented at the Convention.

The following officers were present:
President: Louis B. Wilson, Mayo Foundation.
Secretary: Edward Ellery, Union.
Executive Committee: F. F. Lloyd, McGill.

4. MINUTES OF THE PROCEEDINGS OF THE THIRTY-THIRD CONVENTION:

The account of the proceedings of the Thirty-third Convention of the Society at Atlantic City, December 28, 1932, published in the March, 1932, QUARTERLY, was approved as printed.

5. REPORT OF THE PRESIDENT:

See page 34 this issue.

6. REPORT OF THE TREASURER:

See page 39 this issue.

7. FORMAL PETITIONS:

The Secretary presented formal petitions from Tulane University and the Massachusetts Institute of Technology, and stated that the Executive Committee recommended favorable action. It was

Voted—*a*. That the petition from Tulane University be granted;
b. That the petition from the Massachusetts Institute of Technology be granted.

8. CERTIFICATES OF AWARD IN COMMENDATION OF RESEARCH:

The attention of the Convention was called to the action of the Thirty-second Convention, authorizing the Executive Committee to present certificates of award in commendation of research to students in institutions where there is no chapter of Sigma Xi. (See President's Report, page 34 this issue.) Actual certificates were exhibited to the delegates. They read as follows:

THE SOCIETY OF SIGMA XI
DEVOTED TO THE PROMOTION OF RESEARCH IN SCIENCE
BY THIS DIPLOMA CERTIFIES THAT
THE RECORD MADE BY
(Name of student)
IN
(Name of institution)
AND THE THESIS
(Title of theses)
ARE WORTHY OF SPECIAL COMMENDATION
IN 1933 BY THE SOCIETY
(Signed) LOUIS B. WILSON, *President*
EDWARD ELLERY, *Secretary*

9. AMENDMENT TO CONSTITUTION:

In accordance with the report of the Executive Committee made to and approved by the Thirty-second Convention, the following amendment to the Constitution was proposed:

> The Executive Committee is empowered to elect as associates in the Society students in institutions where there is no chapter of Sigma Xi who have shown marked excellence in two or more fields of science, pure or applied, and to provide for their initiation.

President Wilson announced that in accordance with the Constitution, action on the proposal must be postponed to the 1934 Convention, but invited discussion.

The discussion emphasized the following points:

a. If the amendment were adopted, selection of candidates could best be made by chapters neighboring to the institution in which the candidate had done his work;

b. Election and initiation of associates is now the responsibility of duly constituted chapters, and the responsibilities of the Executive Committee should not be increased to the extent of delegating to it the power to elect;

c. Such a "long distance" election as the amendment proposes is not desirable nor wise.

10. THE SEMI-CENTENNIAL:

The President directed attention to the tentative program as suggested in his report, and asked that delegates (or their chapters) submit to the Secretary in writing suggestions about this important event.

11. ASSESSMENT FOR 1934:

The Treasurer presented the following resolutions, stating that they came to the Convention with the approval of the Executive Committee:

(See Executive Committee Minutes.)

It was

Voted—That the Convention ratify the action of the Executive Committee regarding these resolutions.

12. ELECTION OF OFFICERS:

The Nominating Committee, consisting of Prof. Harlow Shapley, Harvard, Chairman; Prof. J. A. Anderson, California Institute of Technology; and Prof. M. A. Bessey, Michigan State College, presented through the Chairman the following recommendations:

For President—Prof. George Howard Parker, Harvard.
For Secretary—Prof. Edward Ellery, Union.
For Treasurer—Prof. George B. Pegram, Columbia.
For Member of the Executive Committee—Prof. L. J. Stadler, Missouri.
For Member of the Alumni Committee—Harold F. Norton, Newport News, Virginia.

Nominations from the floor were called for by the President. The name of Prof. R. A. Gortner was presented for the presidency.

President Wilson appointed H. J. Creighton, Swarthmore, and F. C. Schmidt, Union, as tellers. The vote for President was announced as Professor Parker 27, and Professor Gortner 7. President Wilson declared Professor Parker elected as President for the ensuing biennium. It was

Voted—That the Secretary be empowered to cast a ballot for the other officers as named.

President Wilson declared the officers elected as named by the Committee.

13. GENERAL BUSINESS:

The Syracuse Chapter asked for information regarding the qualifications for election as associates in the Society.

The question provoked considerable discussion, with Lehigh, Michigan, Yale, Rensselaer, Minnesota, Swarthmore, Union, Harvard, Pennsylvania State, Iowa, and Duke participating.

The Secretary directed attention to a reply made by the Executive Committee to an inquiry from the Lehigh Chapter to the effect that the qualifications for associateship in the Society as defined in the Constitution represented minimum requirements, and that chapters could add other qualifications as they considered called for by conditions in their respective institutions.

14. ADJOURNMENT:

The Convention adjourned at 6.00 P.M.

EDWARD ELLERY, *Secretary*

The Annual Buffet Supper

Delegates and members and guests, to the number of fifty, assembled in Parlor B of the Statler Hotel at 6.30 P.M. for the annual buffet supper.

The Twelfth Annual Lecture

The Twelfth Annual Sigma Xi Lecture was given in the ballroom of the Hotel Statler by Prof. Henry E. Sigerist of Johns Hopkins University, on "The Foundation of Anatomy in the Renaissance." The lecture was illustrated by lantern slides. The audience numbered about eight hundred.

REPORT OF THE PRESIDENT

Your President reports the activities of the Society for 1933 as follows:

1. Two chapters have been added to the Society—that at Duke University, installed March 31 with Secretary Ellery and Treasurer Pegram as the installing officers; and that at the University of California at Los Angeles, installed April 25 with Prof. Charles J. Chamberlin of the University of Chicago and Dr. John A. Anderson of the Mt. Wilson Observatory as the installing officers.

A Sigma Xi Club has been organized during the year at Ohio University in Athens, Ohio; and at Massachusetts State College in Amherst, Massachusetts.

The Society now numbers sixty-two chapters and thirty-three clubs. The total enrollment of members and associates in the chapters amounts to approximately 12,000 individuals. If the Convention acts favorably on the petitions to be presented at this meeting, Sigma Xi will be found in almost every university and technical school in this country which has one or more departments of science doing research work.

2. During the year your Executive Committee has been giving intimate scrutiny to equipment, material resources, and the research spirit at a number of institutions in which groups of members and associates of the Society are desirous of establishing a chapter of Sigma Xi. Official visitors have been appointed to make personal survey of a few of these colleges, and painstaking inquiry about others has been made among members of the Society who are in position to report accurately on existing conditions. It is probable that the Committee will make definite report at some later meeting about many of these institutions.

In accordance with the action of the Committee, there are presented to you today, with recommendation to favorable action, two formal petitions for charters for chapters—one from Tulane University and one from the Massachusetts Institute of Technology.

3. The Convention will recall that at the meeting held in New Orleans, December 29, 1931, approval was given to the proposal to issue to properly accredited students in institutions where there are no chapters of the Society, certificates in commendation of scientific work done by young men and women in those colleges or universities or technical schools.

In response to an invitation issued in accordance with that approved proposal, eleven institutions submitted records of standing and theses of thirty students.

The Executive Committee, at the meeting of June 21, 1933, voted that as a principle the theses should be read by a committee from some one institution—a different one for each year—in order to allow opportunity for conference among the members of the Committee, and to give surer basis for comparison and evaluation of the work of each candidate.

Pursuant to that action, your President appointed the following committee of award for 1933, from Union College and the Research Laboratory of the General Electric Company at Schenectady:

Dean Ernest J. Berg, Department of Electrical Engineering.
Prof. Frederick W. Grover, Department of Electrical Engineering.
Prof. Charles B. Hurd, Department of Chemistry.
Prof. Egbert K. Bacon, Department of Chemistry.
Prof. Leonard B. Clark, Department of Biology.
Prof. Frank J. Studer, Department of Physics.
Dr. Saul Dushman, Research Laboratory.
Mr. E. F. Hennelly, Research Laboratory.

The task of reading the theses and scrutinizing the scholastic record of the candidates was a considerable one, and required much of the summer. The final awards of the Committee for 1933 are as follows:

University of Alabama:

John N. Chatfield and *Raymond B. Hunze*—A New Use of the Vacuum Tube in Electrometric Titrations. I. Polarization of Platinum Electrodes in Oxidation and Reduction Reactions.

Brooklyn Polytechnic Institute:

Russell C. Buehl—The Use of a Thyratron Tube for Maintaining a Motor Generator Set in Synchronism with a Regulated Supply.

Richard A. Carroll—Attempted Condensation of Primary Amines with Salts of Methyl-iso-thio-urea and Dicyan-diamide.

Bernard Gross—The Compatibility of Shellac in Lacquer for Airplane Coating.

George C. Moog—An Experimental Study of Proximity Effect in Large Closely Associated Direct Current Conductors.

Frank H. Rae—The Study of Thyrite for Use in the Determinations of a Wheatstone Bridge Relay Circuit.

P. Peter Regna—A Study of the Behavior of the Antimony Antimonous Trioxide Electrode.

Herman Schneider—The Microscopic Identification of the Elements of the Platinum Group and Gold.

Emil Fridstein Vaage—An Electric Arc in Double Energy Circuits. Theoretical Study and Applications to Transmission Line Problems.

Joseph J. Vetter—Design of an Air Evaporator.

Connecticut State College at Storrs:

David Lackman—A Study of a Bacterial Disease of Cold-blooded Animals with Special Reference to the Problem of Immunity.

Massachusetts State College at Amherst:

Jay L. Haddock—Studies of Methods for Determination of Magnesium Deficiency in Soils.

North Dakota Agricultural College at Fargo:

Gale Monson—Migrational Study of the Birds of Berlin and Harwood Townships, Cass County, North Dakota.

Smith College:

Elizabeth A. Copeland—Coat Coloration in the House Mouse. The Chinchilla Factor in Non-agouti Combinations.

Madeleine P. Grant and *Myra L. Johnson*—The Histogenesis of the Clavicle in the Albino Rat. (By Miss Johnson alone) The Time and Order of Appearance of Ossification Centers in the Albino Mouse.

Katharine L. Pease—Effect of Injections of Amphibian Anterior Pituitary Upon the Guinea Pig Ovary.

Mary Langford Stearns—A Study in Tissue Culture Technique. Cultivation of Embryonic Chick Heart Tissue in Vitro.

University of Vermont:

Robert T. Conner—Preparation of Several Mono-Guanidine Derivatives.

The certificates of award are here for your inspection today. They will be sent to the respective institutions immediately following this Convention.

4. In accordance with further action of the New Orleans Convention, and after further consideration by your Executive Committee, the following amendment to the Constitution is now proposed:

> The Executive Committee is empowered to elect as associates of the Society a limited number of students in institutions where there is no chapter, who have shown marked excellence in one or more departments of pure or applied science, and to provide for their initiation.

A discussion of this proposed amendment is invited at this time. In accordance with the Constitution, action on it may not be taken until the Convention of 1934.

5. During the coming year the program for the Semi-centennial at Ithaca in the summer of 1936 must take on definite shape. Your Executive Committee has under consideration the following tentative proposals:

1. The morning session:

a. Greetings from the President of Cornell University and from a representative of the Cornell Chapter.

b. Presentation of the founders of the Society who may still be living.

c. A history of the Society.

d. An address on "Ancient and Modern Ways of Awarding Honors."

2. The afternoon session:

a. Address on "Interdependence of Research Work Among Fields of Science."

b. Addresses on the affirmative and negative side of the question "Has Research in Science Justified Itself?"

c. Addresses: "The Place of the Scientist Fifty Years Ago." "The Place of the Scientist Today."

3. The evening session:

Address by some philosopher: "The Influence of Science on Man's Mental and Moral and Spiritual Progress."

4. The Atlantic City Convention, December 28, 1932, voted that the income from the Society's invested funds should be segregated for the purpose of making awards for research now in progress, and that the first such award should be made at the Semi-centennial. The incoming President of the Society is authorized by the Convention to name a committee to study and propose methods of procedure in connection with such award or awards.

5. Your Executive Committee also proposes that the Semi-centennial be made the occasion to pronounce citations for meritorious service in promoting research, selecting for such citation one individual from each of the nine scientific fields which Sigma Xi represents. During the coming year chapters will be asked to consider possible candidates for such citations, and to be prepared to name them to the Executive Committee when called upon to do so.

6. Contributions to the fund for grants-in-aid of research are this year very limited in number and amount. To date, they total $300. In order to reduce the expenses of collection, the September issue of the QUARTERLY enclosed a blue slip soliciting contributions from alumni members and associates, and at the spring meeting the Executive Committee allotted the sum of $1,000 from the Society's funds to the Committee of Award for distribution among the applicants.

The Committee of Award was: Dr. W. R. Whitney, director of research, General Electric Company; Prof. Gary N. Calkins, Columbia University; and Prof. Harlow Shapley, Harvard University.

There were twelve applications for grants, and the Committee made awards as follows:

Charles Ernest Braun, associate professor of organic chemistry, University of Vermont, $150 for continuance of the study of the relationship between guanidine structure and hypoglycemic activity.

Fred Wilbert Emerson, professor of biological science, New Mexico Normal University, $60 for study of the adjustment of plants to the peculiar life conditions of the white sands near Alamogordo, New Mexico.

Edwin T. Hodge, professor of geology, Oregon State Agricultural College, $100 for analytical work in connection with a large suite of Oregon rocks.

C. J. Krieger, professor of astronomy, University of St. Louis, $100 for publication of a paper on "Preliminary Table of Lines in the Spectrum of Delta Cephei."

Ruth Marshall, professor of zoology, Rockford College, $100 for continuance of work on hydracarina of Wisconsin.

T. L. Smith, professor of zoology, College of the Ozarks, Clarksville, Arkansas, $150 for research on a species of lepidoptera-galleria mellonella L.

7. At the spring meeting of your Executive Committee, the Secretary was directed to correspond with those Sigma Xi clubs whose activities and interest and enthusiasm warranted the suggestion, recommending to them the possibility of forming an alumni chapter in their locality. Already there have been applications for the establishment of such alumni chapters at the University of Arkansas and the University of Florida. Correspondence has passed between the Secretary's office and other institutions, and further applications may be expected in the near future. Your Executive Committee is giving careful consideration to this movement to bring Sigma Xi clubs into closer relation to the national organization.

8. Your President wishes to take the occasion of this annual report to the Society to express his profound appreciation of the sincere interest and enthusiastic cooperation and painstaking consideration of the Society's affairs which the national officers have constantly shown throughout his administration. Sigma Xi grows in importance and influence as the years pass. The entire membership may rest assured that the business of the Society will be conducted with the utmost care, and that the objects of the Society will be conservatively met.

LOUIS B. WILSON, *President*

December 20, 1933.

REPORT OF THE TREASURER

The 1933 assessments of all chapters, except the District of Columbia and the University of Illinois, both of whose funds are tied up in closed banks, were paid within the year.

RECEIPTS

Cash on hand, January 1, 1933	$ 5,914.27	
Chapter assessments for 1933	5,538.47	
Chapter assessments for 1933 redeposited, bank holiday	156.75	
Chapter assessments for 1932, arrears	87.75	
Chapter assessments for 1934, advance	136.75	
Initiation fees for 1933	2,567.00	
Initiation fees for 1932, arrears	229.00	
Installation fees	50.00	
QUARTERLY	12.25	
Interest on investments	817.50	
Sale of insignia	870.46	
Sale of Public Service Elec. & Gas Co. 4% bond	1,010.71	
		$17,390.91

DISBURSEMENTS

Secretary's office (total—$3,719.72):		
Assistants	$ 1,706.40	
Office—general	213.32	
Secretary's stipend	1,800.00	
Treasurer's office (total—$165.62):		
Assistant	150.00	
Auditing 1933 books	10.00	
Telegrams	5.62	
Officers' traveling expenses	538.00	
QUARTERLY (4 issues)	1,716.86	
Engrossing charters	96.60	
3 U. S. Treasury 3% bonds	2,827.50	
2 Public Service Elec. & Gas. Co. 4% bonds	1,845.00	
Accrued interest on above bonds	44.83	
Checks returned, banks closed	156.75	
Check tax	1.62	
Loaned Alumni Fund, 1933	290.53	
Cash on hand, December 31, 1933	5,987.88	
		$17,390.91

INVESTMENT ACCOUNT—GENERAL

The current market value of most of these bonds is much below the purchase price as listed below, particularly for the railroad bonds. All the companies continue to pay interest on their bonds except the St. Louis and San Francisco Railway, which is in receivership.

$1,000 Amer. Tel. & Tel. 5½% bond at	$ 1,037.44
$1,000 Amer. Tel. & Tel. 5½% bond at	991.94

$1,000 Consolidated Gas of New York 5¼% bond at	1,002.90	
$1,000 St. Louis & San Francisco Railway 4% bond at	796.35	
$1,000 Baltimore & Ohio Railway 5% bond at	955.00	
$1,000 Pacific Gas & Electric Co. 5¼% bond at	1,045.00	
$1,000 Philadelphia Co. 5% bond at	979.50	
$1,000 Erie Railroad Co. 5% bond at	947.00	
$1,000 Southern Railway Co. 6% bond at	1,152.00	
$1,000 Western Electric Co. 5% bond at	1,029.50	
$1,000 Philadelphia Co. 5% bond at	997.00	
$1,000 New York Central 6% bond at	1,032.00	
$1,000 Canadian Pacific 5% bond at	1,010.00	
$1,000 Amer. Tel. & Tel. 5% bond at	1,077.50	
$1,000 U. S. Treasury 4% bond at	999.06	
$1,000 U. S. Treasury 4¼% bond at	999.06	
$1,000 New York Telephone Co. 4½% bond at	997.50	
$1,000 U. S. Treasury 3% bond at	942.50	
$1,000 U. S. Treasury 3% bond at	942.50	
$1,000 U. S. Treasury 3% bond at	942.50	
$1,000 Public Service Elec. & Gas Co. 4% bond at	922.50	
$1,000 Public Service Elec. & Gas Co. 4% bond at	922.50	
		$21,721.25

Alumni Fund

RECEIPTS

Cash on hand, January 1, 1933	$ 000.00	
Receipts from subscriptions	386.05	
Credited in error to Alumni Fund	3.00	
Refund from Seward E. Owen	33.42	
Redeposited on account, bank holiday	6.00	
Interest on investments	90.00	
Borrowed from General Fund	290.53	
		$ 809.00

DISBURSEMENTS

Research:		
Norman E. A. Hinds, 1932-33	$ 150.00	
Rachel E. Hoffstadt, 1932-33	125.00	
Charles Vincent Taylor, 1932-33	250.00	
Charles E. Braun, 1932-33	75.00	
Ruth Marshall, 1933-34	100.00	
C. J. Krieger, 1933-34	100.00	
	$ 800.00	
Checks returned, bank holiday	6.00	
Transferred to General Fund (initiation fees)	3.00	
Cash on hand, December 28, 1933	000.00	
		$ 809.00

INVESTMENT ACCOUNT—ALUMNI FUND
(Securities carried at cost)

$1,000 Southern Pacific Co. 4½% bond at	$ 905.75	
$1,000 Southern Pacific Co. 4½% bond at	907.00	
		$ 1,812.75

GEORGE B. PEGRAM, *Treasurer*

December 31, 1933.

We have audited the accounts of the Treasurer of the Society of Sigma Xi for the year ending December 31, 1933, and certify that the income shown by the books of the Treasurer has been duly accounted for, that payments have been properly vouched and that the balance sheet and accounts submitted contain a true statement of the financial condition of the Society. We have also examined the securities in the hands of the Treasurer and find the following bonds: $1,000 Amer. Tel. & Tel.; $1,000 Amer. Tel. & Tel.; $1,000 Consolidated Gas of New York; $1,000 St. Louis & San Francisco Railway; $1,000 Baltimore and Ohio Railway; $1,000 Pacific Gas & Electric Co.; $1,000 Philadelphia Co.; $1,000 Erie Railroad Co.; $1,000 Southern Railway Co.; $1,000 Western Electric Co.; $1,000 Philadelphia Co.; $1,000 New York Central; $1,000 Canadian Pacific; $1,000 Amer. Tel. & Tel.; $1,000 U. S. Treasury; $1,000 U. S. Treasury; $1,000 New York Telephone Co.; $1,000 U. S. Treasury; $1,000 U. S. Treasury; $1,000 U. S. Treasury; $1,000 Public Service Elec. & Gas Co.; $1,000 Public Service Elec. & Gas Co.; $1,000 Southern Pacific; $1,000 Southern Pacific.

L. BRETT,
J. T. FINNERAN,
Auditors

CHAPTER OFFICERS

List Furnished by the Secretaries of the Chapters

CHAPTER	PRESIDENT	VICE-PRESIDENT	SECRETARY	TRE
Cornell	L. A. Maynard	P. M. Lincoln	G. E. Grantham	A. J. Hen
Rensselaer	A. W. Bray	I. L. Rosenholtz	F. M. Sebast	H. E. Sm
Union	C. B. Hurd	E. S. C. Smith	F. J. Studer	F. J. Stu
Kansas	H. H. Lane	C. M. Young	E. L. Treece	H. E. Jon
Yale	G. A. Garratt	B. F. Dodge	L. S. Stone	H. H. W
Minnesota	S. C. Lind	F. K. Butters	F. B. Hutt	G. A. Th
Nebraska	T. A. Kisselbach	D. A. Worcester	E. N. Anderson	M. G. Co
Ohio	J. F. Lyman	E. M. Spieker	F. A. Hitchcock	F. A. Hu
Pennsylvania	H. C. Bazett	C. P. Olivier	E. P. Helwig	P. A. Cr
Brown	H. C. Bumpus	W. A. Noyes	P. H. Mitchell	W. R. Ba
Iowa	H. A. Mattill	N. C. Meier	F. T. Mavis	Roscoe W
Stanford	G. M. Smith	C. H. Danforth	P. R. Farnsworth	P. R. Far
California	R. T. Crawford	R. W. Chaney	G. E. Troxell	S. F. Cod
Columbia	M. T. Bogert	H. W. Webb	A. W. Thomas	A. W. Th
Chicago	F. C. Koch		W. C. Pierce	C. G. Cra
Michigan	E. H. Kraus	C. V. Weller	L. S. Ramsdell	A. A. Chr
Illinois	W. C. Rose	F. W. Loomis	A. R. Cahn	T. S. Ha
Case	F. L. Plummer	A. A. Bates	C. W. Wallace	T. M. Fo
Indiana	P. Weatherwax	P. M. Harmon	C. M. Louttit	W. D. Th
Missouri	M. M. Ellis	M. J. Guthrie	F. F. McKenzie	G. F. Bre
Colorado	K. F. Muenzinger	F. S. Bauer	H. B. Van Valkenburgh	W. K. Ne
		E. R. Mugrave		
Northwestern	J. P. Simonds	W. H. Burger	F. T. Gucker	Elizabeth
Syracuse	C. C. Carpenter	R. R. Hirt	J. M. Robeson	E. T. Ap
Wisconsin	E. M. Gilbert	H. W. March	H. W. Mossman	H. R. Al
Univ. of Wash.	E. A. Loew	C. L. Utterback	R. H. Gundlach	R. B. Vin
Worcester	T. H. Morgan	F. R. Butler	W. E. Lawton	H. W. Da
Purdue	H. E. Enders	L. V. Ludy	R. H. George	Marguerite
Washington Univ.	G. E. M. Jauncey	F. W. Bubb	W. D. Shipton	R. R. Tuc
Dist. of Columbia	A. Wetmore	Wm. Bowie	Miss Vinnie Pease	Wm. Lerch
Texas	F. M. Bullard	H. L. Lochte	Jet C. Winters	R. H. Cay
Mayo Foundation	H. F. Helmholz	J. C. Masson	J. L. Bollman	J. L. Boll
N. Carolina	R. E. Coker	E. T. Browne	E. L. Mackie	E. L. Mac
N. Dakota	R. R. Hitchcock	G. A. Talbert	R. C. Staley	R. C. Sta
Iowa State College (formerly *Ames*)	H. Gilman	E. R. Becker	J. L. Lush	R. A. Cas
Rutgers	H. E. Starr	T. C. Nelson	R. d'E. Atkinson	M. A. Ch
McGill	W. G. McBride	J. B. Collip	D. L. Thompson	C. L. Hu
		J. J. O'Neill		
Kentucky	F. E. Tuttle	H. H. Downing	E. M. Johnson	J. S. McH
Idaho	Ella Woods	J. Nordby	J. Buchanan	A. M. Sow
Swarthmore	W. J. Scott	M. W. Garrett	H. J. Creighton	H. J. Cre
Oregon	L. F. Henderson	I. Manville	Rosalind Wulzen	F. L. Shi
Virginia	C. C. Speidel	J. W. Beams	E. M. Betts	E. M. Bet
Johns Hopkins	A. H. Pfund	A. M. Chesney	M. W. Pullen	F. D. Mur
Calif. Inst. of Technology	I. A. Anderson	R. R. Martel	W. R. Smythe	R. T. Kru
New York	R. R. Renshaw	C. W. Lytle	H. G. Lindwall	H. G. Lin
Cincinnati	S. Tashiro	R. A. Kehoe	S. B. Arenson	S. B. Are
Mich. State	R. C. Huston	Marie Dye	V. G. Grove	R. E. Mar
Arizona	G. T. Caldwell	E. L. Scott	R. B. Streets	R. B. Sto
Lehigh	I. S. Long	A. Ford	P. L. Bayley	R. D. Pil
Maryland	L. B. Broughton	I. E. Metzger	M. M. Haring	M. M. Ha
Kansas State	J. H. Parker	H. W. Cave	R. C. Smith	J. L. Hal
Col. of Medicine, Univ. of Illinois	A. Bachem	C. B. Puestow	W. H. Welker	I. Pilot
Pennsylvania State	E. D. Walker	R. A. Dutcher	W. B. Mack	W. L. Hes
Oklahoma	A. I. Ortenburger	N. A. Court	L. E. Swearingen	L. E. Sw
State Col. of Wash.	I. L. St. John	R. L. Webster	J. G. Woodburn	I. G. Wo
Wyoming	A. F. Vass	W. B. Solheim	A. B. Mickey	C. L. Far
Rochester	A. S. Gale	W. S. McCann	Q. D. Singewald	Q. D. Sin
Pittsburgh	O. E. Jennings	C. G. King	R. T. Hance	A. G. Wie
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EDWARD ELLERY,
National Secretary, Sigma Xi,
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Schenectady, N. Y.

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